Table of Content

1 General Information

In this document the Keyless GO and Start System is introduced.

Keyless Entry Systems are the consequent development of well-known Remote Keyless Entry Systems (RKE), the usage of the key fob with button pressing is still possible, but not necessary anymore to enter the vehicle or to start it.

With the Hella Components UID, LF antennas and **Keyless Start ECU** it's possible to equip a vehicle with only a few components and realize this very convenient and luxury feature.

The ECU is built together with Continental Corporation Germany.

Hella is the Engineering Distributer AND Designer for the **part that is to be approved.**

The Model Name of the described ECU is:

MARS Keyless

2 LF- Performance in Typical Application

In the MARS EIS ECU the Hella LF Driver Part is connected with Hella LF Antennas.

A UID – also manufactured from Hella – is to be found inside or outside the vehicle, whether a special occasion happens.

Here are some examples:

- Passive Entry / Exit

A Person with the UID **nears** to the locked vehicle.
If he grabs the door handle capacitive unlock sensor is activated and the complete Keyless Entry Protocol is started. The side LF antenna is transmitting LF data and a carrier signal, which can be recognized and judged by quantity (RSSI-measurement) by the UID.

The measured field strength is sent to the ECU and is judged.

If the magnetic field strength is high enough (a certain border is reached). The doors will unlock.

The additional LF communication guaranties the functionality, that only the valid key OUTSIDE the vehicle authenticates the system to unlock the car passively.

If the magnetic field strength is not high enough (e.g. the UID is too far away from the vehicle, the border is not reached), the UID shuts down again and waits for the next LF Data. The vehicle is still locked.

A Person with the UID **is leaving** the vehicle. If he touches the capacitive lock sensor at the door handle, the complete Keyless Exit Protocol is started:
The side LF antenna is transmitting LF data and a carrier signal, which can be recognized and judged by quantity (RSSI-measurement) by the UID.

The measured field strength is sent to the ECU and is judged.

If the magnetic field strength is high enough (a certain border is reached). The doors will lock.

The additional LF communication guaranties the functionality, that only the valid key OUTSIDE the vehicle authenticates the system lock the car passively. If the UID is left inside the car, the car won't lock.

If the magnetic field strength is not high enough (e.g. the UID is too far away from the vehicle, the border is not reached), the UID shuts down again and waits for the next LF Data. The vehicle is still open.

- Passive Start

A Person with the UID inside of the vehicle is pressing the Start-Stop-Switch. The Start-Stop-Switch activates the complete Keyless Start protocol:

The interior antenna is transmitting the LF Data and a carrier signal, which can be recognized and judged by quantity (RSSI-measurement) by the UID.

The other two interior antennas IN1 and IN2 transmit two additional carrier signals sequential.
If the magnetic field strength of one of these transmits is high enough (a certain border is reached) then the UID authenticates the system to start the vehicle.

If the magnetic field strength of all antenna transmits are too low (the field strength border is not reached, maybe the UID is laying outside or is held 10cm outside the vehicle) the car won't start.

2.1 LF Antenna Positions in Vehicle

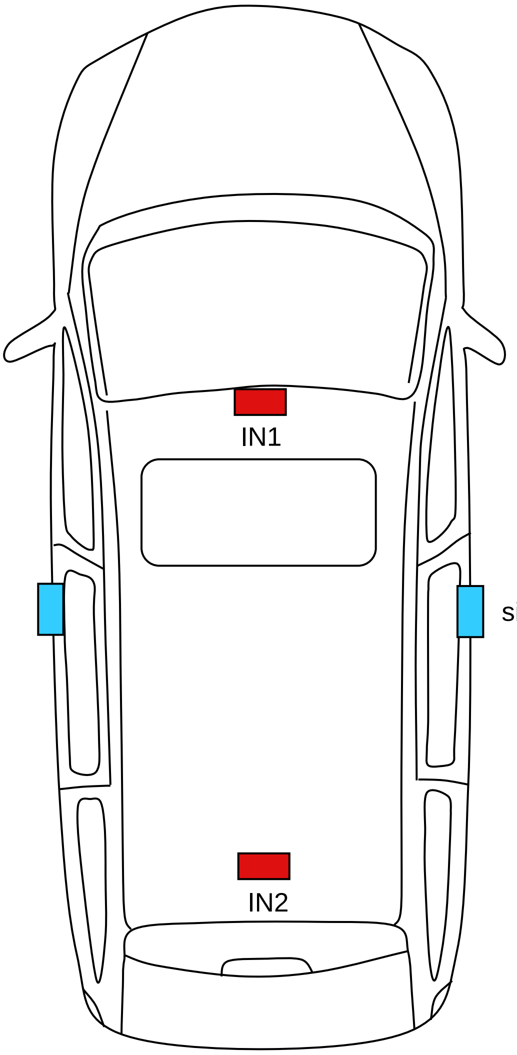


Fig. 1 Antenna Positions at a Keyless Entry / Keyless Start Vehicle

2.2 Authentication Ranges Inside and Outside the Vehicle

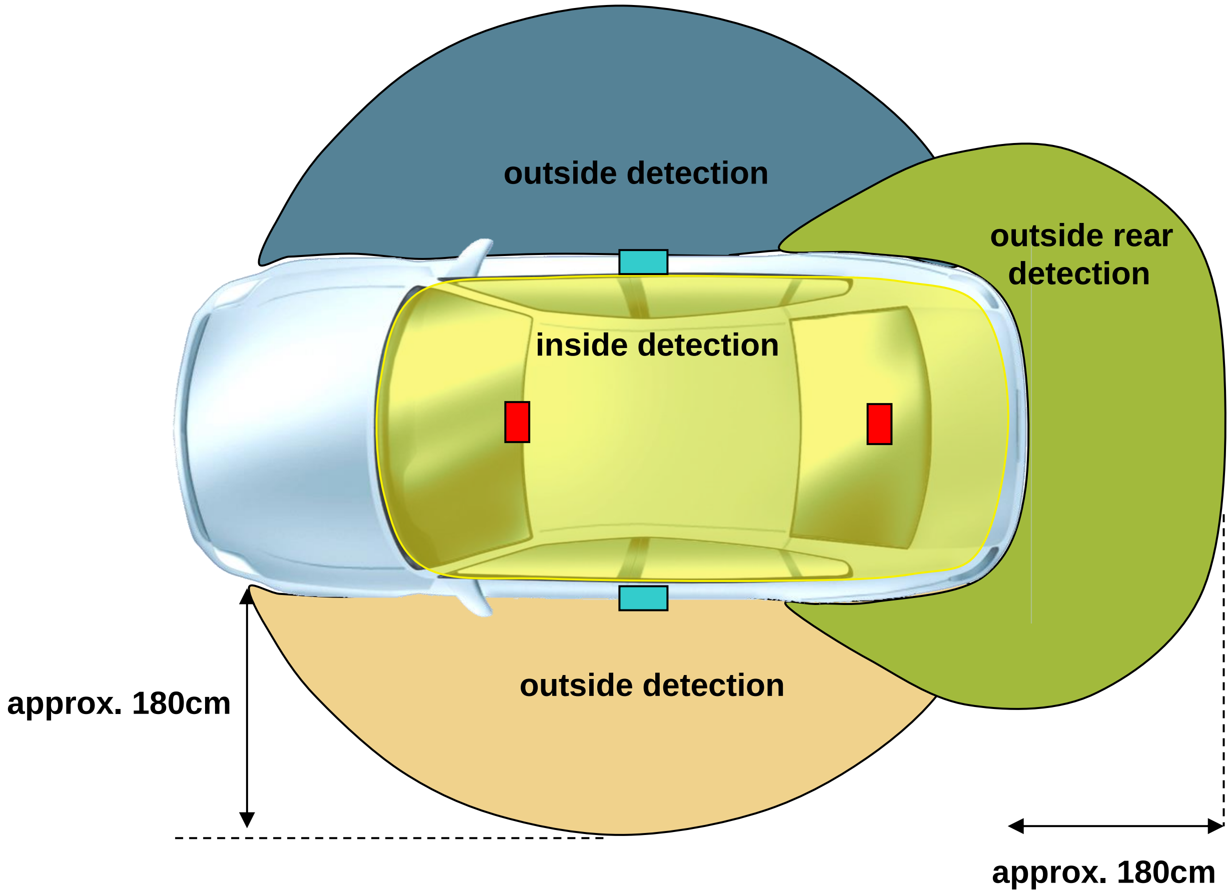


Fig. 2 Principle of Magnetic Field Detection Areas

3 HW-Description

3.1 DAIMLER MARS ECU

The main tasks of the MARS EIS ECU are: Entry/Exit functionality with unlock and lock sensor signal analysis, Keyless Go / Keyless Start functionality, LF-Message transmission, Immobilizing functionality communication with other ECU's on CAN by building a gateway (**not in focus, it's Continental part**).

3.2 ECU Layout

Layer TOP

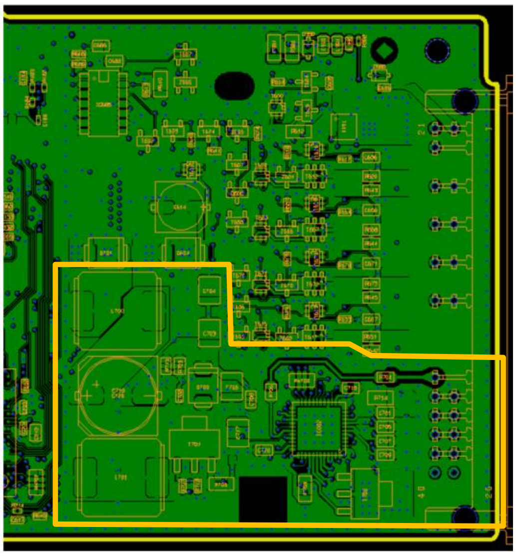


Fig. 3 Layer 1

Layer 2 – incl. Components from Top

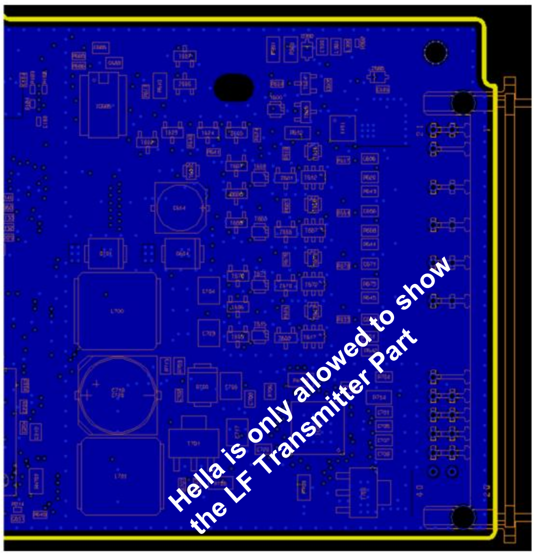


Fig. 4 Layer 2

Layer 3 – incl. Components from Top

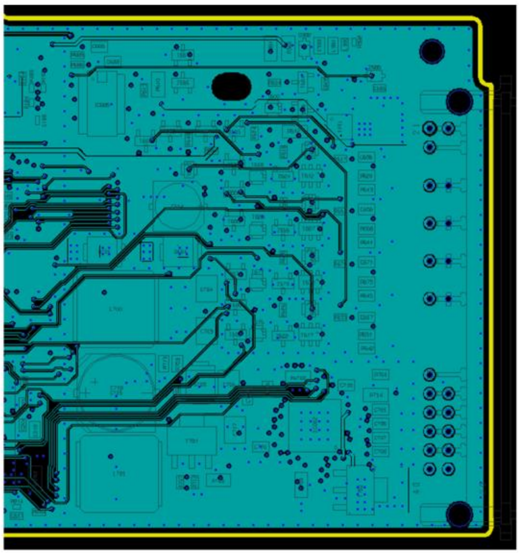


Fig. 5 Layer 3

Layer 4 – incl. Components from Top

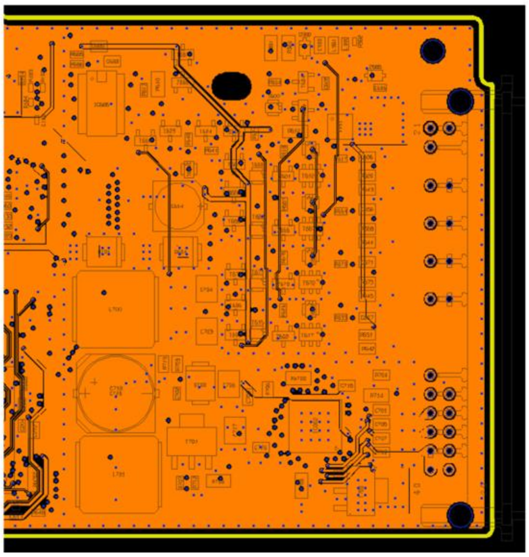
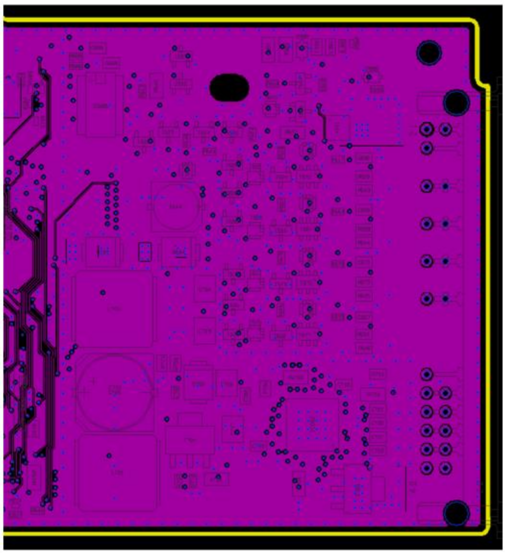


Fig. 6 Layer 4

Layer 5 – incl. Components from Top



Layer 6 – incl. Components from Bottom

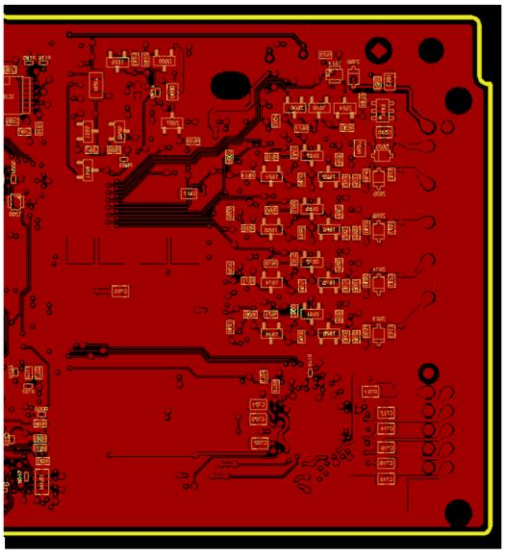


Fig. 7 Layer 5 **Fig. 8 Layer 6**

PCB-Fläche

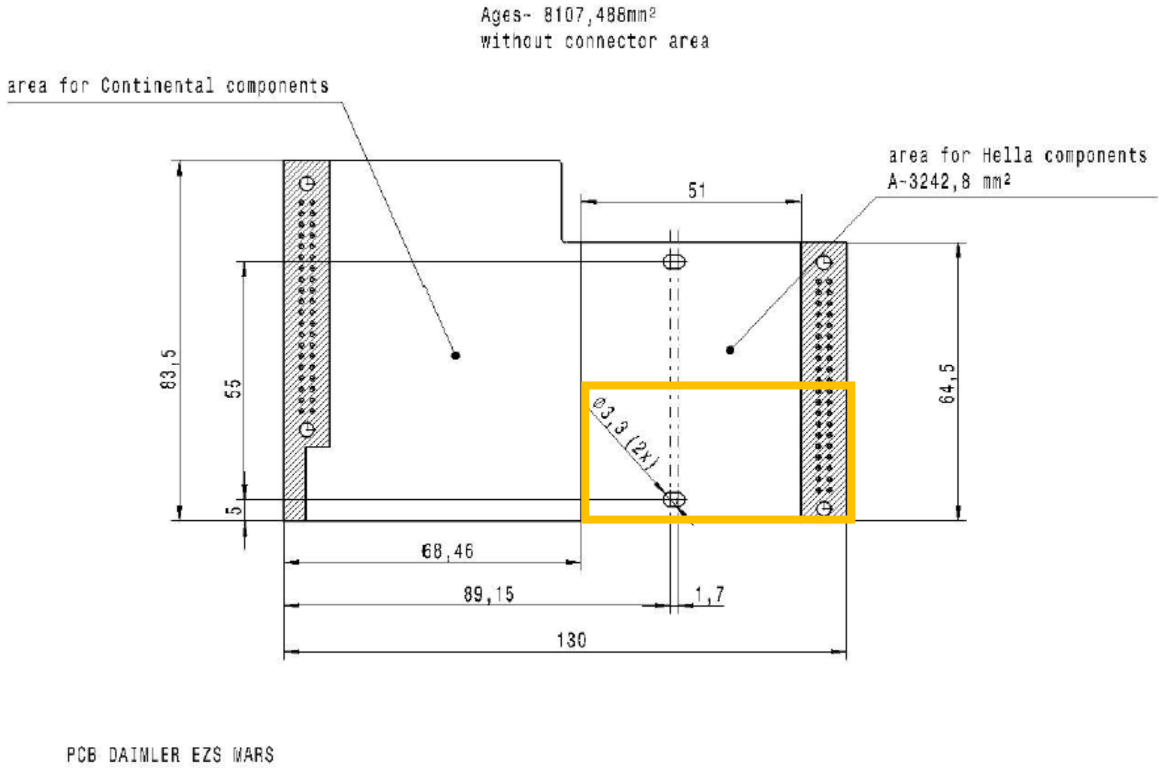


Fig. 9 Layout LF- Driver Part in Detail, marked orange area is to generate f=125kHz-signal

3.3 ECU Schematic

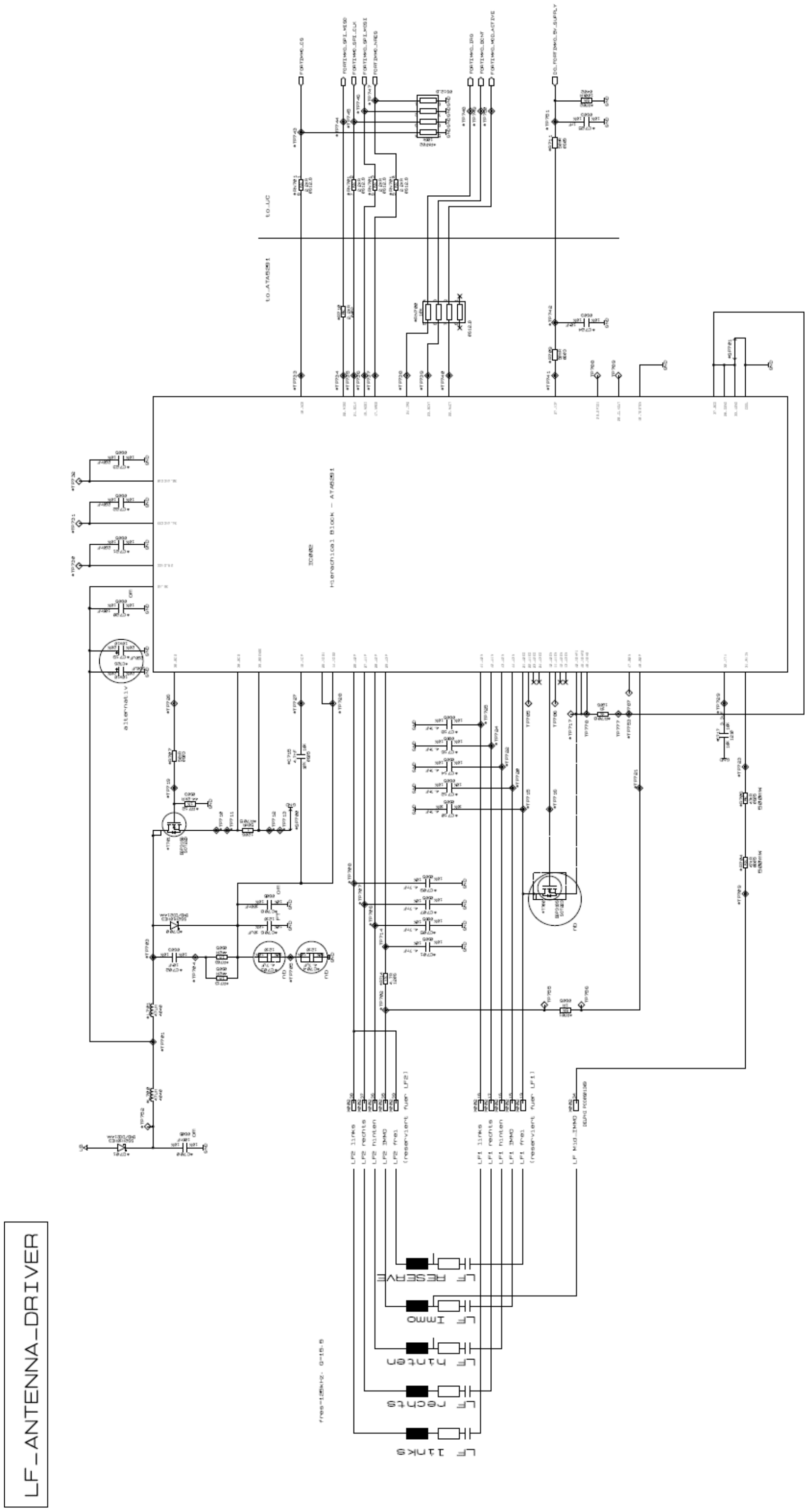


Fig. 10 Schematic of LF Driver Part of MARS EIS ECU

3.4 BOM (Populated Parts) of Hella Part

C600	100p	D670	BAT54	R664	1k
C601	100p	D685	SBAS40LT1G	R665	33.2k
C602	10n	D700	SS2H10HE3	R666	10k
C603	390p	D701	SS2H10HE3	R667	100k
C604	1n	IC002	ATA5291	R670	49.9k
C605	1n	IC685	HEF40106BT	R671	100k
C606	220n	L700	47u	R672	100k
C607	220n	L701	47u	R673	165
C608	1n	R600	10k	R674	499
C609	1n	R601	49.9k	R675	100k
C610	10n	R602	22k	R676	22k
C611	10n	R603	10k	R677	10k
C612	100n	R604	10k	R678	100k
C613	560p	R605	100k	R679	1k
C614	47u	R606	22k	R680	33.2k
C615	100n	R607	49.9k	R681	10k
C616	15n	R608	100k	R682	100k
C617	470n	R609	499	R683	100k
C655	100p	R610	115	R685	100k
C656	220n	R611	10k	R686	49.9k
C657	1n	R612	1,24	R687	115
C658	10n	R613	49.9k	R688	22k
C659	15n	R614	100k	R689	10k
C670	100p	R615	499	R690	3.3k
C671	220n	R616	100k	R701	1
C672	10n	R617	1k	R702	100k
C673	15n	R618	33.2k	R703	442
C674	1n	R619	100k	R704	47k
C685	100n	R620	165	R705	50m
C686	560p	R621	100k	R706	47k
C687	390p	R622	100k	R707	50m
C688	100n	R623	22k	R708	1
C700	100n	R624	49.9k	R709	50m
C701	4.7n	R625	100k	R710	2.2k
C702	10n	R626	100k	R711	50m
C703	4.7u	R627	5.62k	R712	44.2k
C704	4.7u	R628	100k	R713	442
C705	4.7n	R629	22k	R714	4,7
C706	10u	R630	10k	RN700	10k
C707	4.7n	R631	165	RN701	2.2k
C708	100n	R632	100k	RN702	100k
C709	4.7n	R633	1k	T600	SMUN5313DW1
C710	4.7n	R634	33.2k	T601	SMUN5313DW1
C712	4.7n	R635	10k	T602	SMMUN2213LT3
C714	4.7n	R636	100k	T603	BC817C
C715	4.7n	R637	10k	T604	SMMUN2213LT3
C716	4.7n	R638	100k	T605	BC817C
C717	3.3u	R639	10k	T606	SMMUN2213LT3
C718	4.7n	R640	4.99k	T607	BC817C
C719	220u	R641	49.9k	T608	SMUN5313DW1
C720	100n	R642	165	T609	BC807C
C721	220n	R643	165	T610	BC807C
C722	220n	R644	165	T611	NVTFS5124PL
C723	220n	R645	165	T612	SQ3427EV
C724	10n	R647	100k	T613	SMUN5313DW1
C725	1n	R648	1k	T614	SMUN5313DW1
C726	330u	R655	49.9k	T615	SMUN5313DW1
D600	SBAS40LT1G	R656	100k	T616	SMUN5313DW1
D601	BAT54	R657	100k	T617	SQ3427EV
D602	BAT54	R658	165	T618	SMMUN2213LT3
D603	BAS21	R659	499	T619	SQ3427EV
D604	SS2H10HE3	R660	100k	T620	BC807C
D605	BAV70	R661	22k	T621	BC807C
D655	BAT54	R662	10k	T622	BC807C
D656	BAV70	R663	100k	T623	BC817C

This list is NOT to be shown to third parties!!!

Parts used in Hella schematic part that is to be approved.

T624	BC817C
T655	BC817C
T656	SMUN5313DW1
T657	SQ3427EV
T658	SMUN5313DW1
T659	BC807C
T660	BC807C
T670	BC817C
T671	SMUN5313DW1
T672	SQ3427EV
T673	SMUN5313DW1
T674	BC807C
T675	BC807C
T685	BC817C
T686	SMMUN2213LT3
T687	BC817C
T700	BSP318S
T701	BSP318S

This list is NOT to be shown to third parties!!!

Parts used in Hella schematic part that is to be approved.

Table 1 BOM of populated parts

Hella 8303EN_GE (2004-09)

3.5 Block Diagram of Related Functional Modules

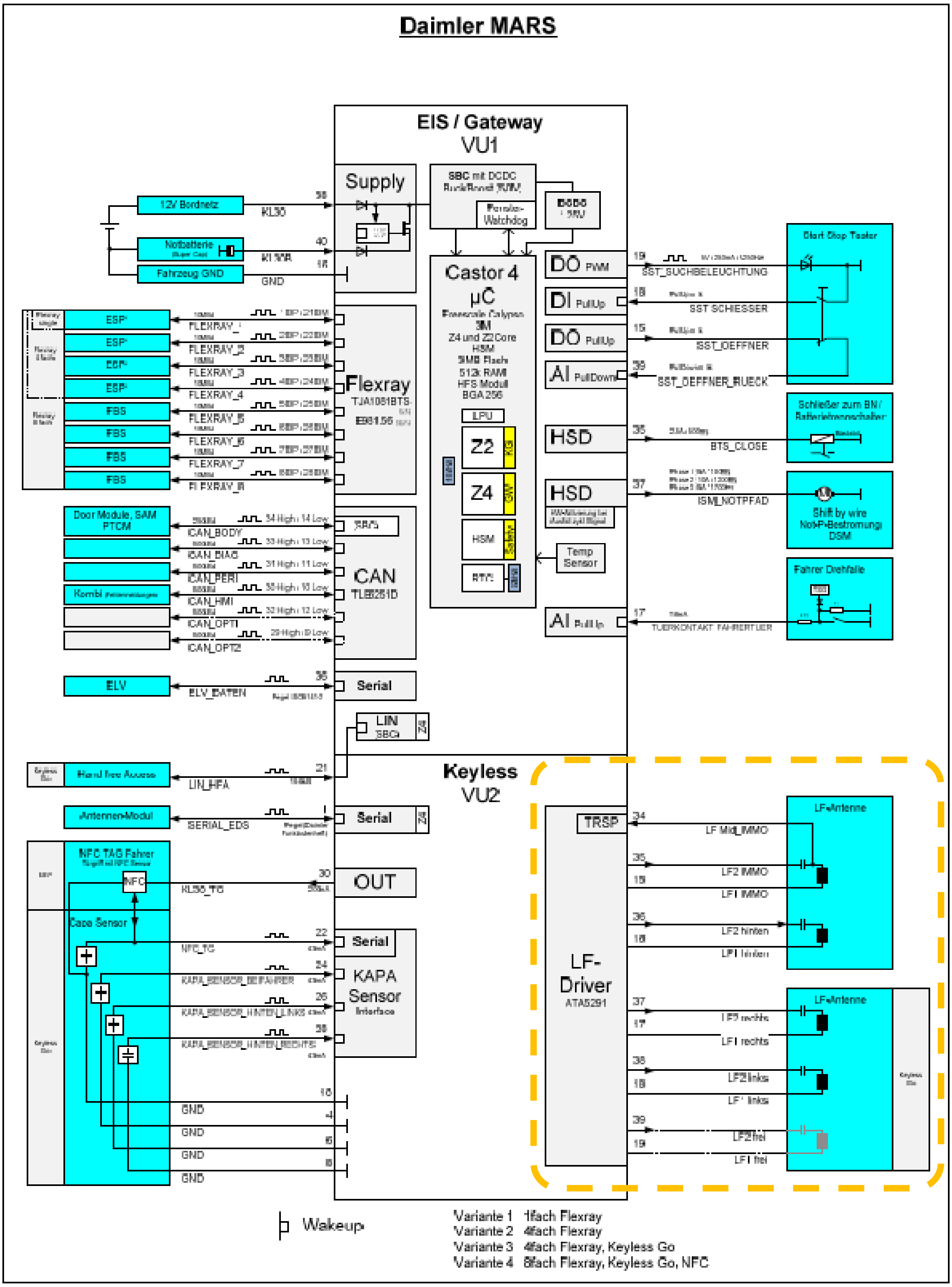


Fig. 11 Block diagram of modules in the ECU, LF driver in orange marked area

4 LF-Driver Hardware Module with 5291

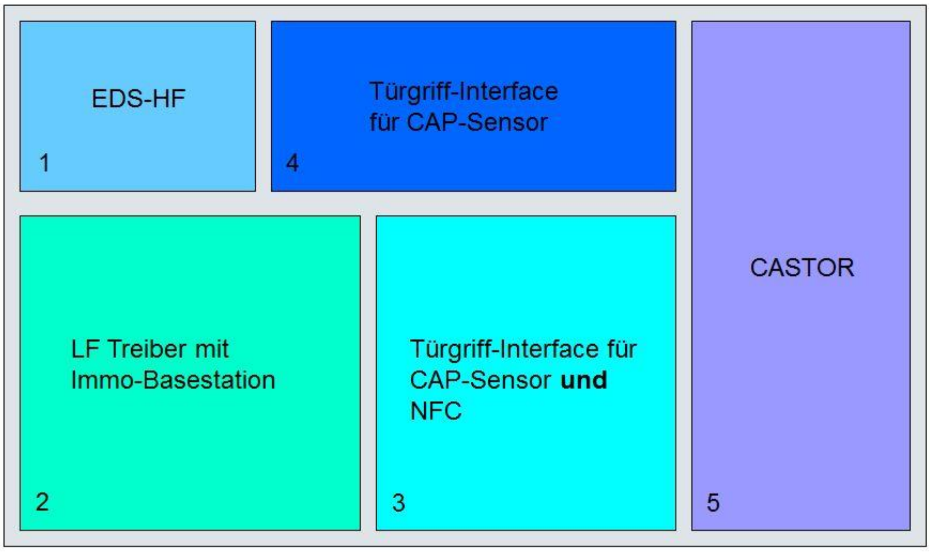


Fig. 12 Block diagram, architecture of Hella part

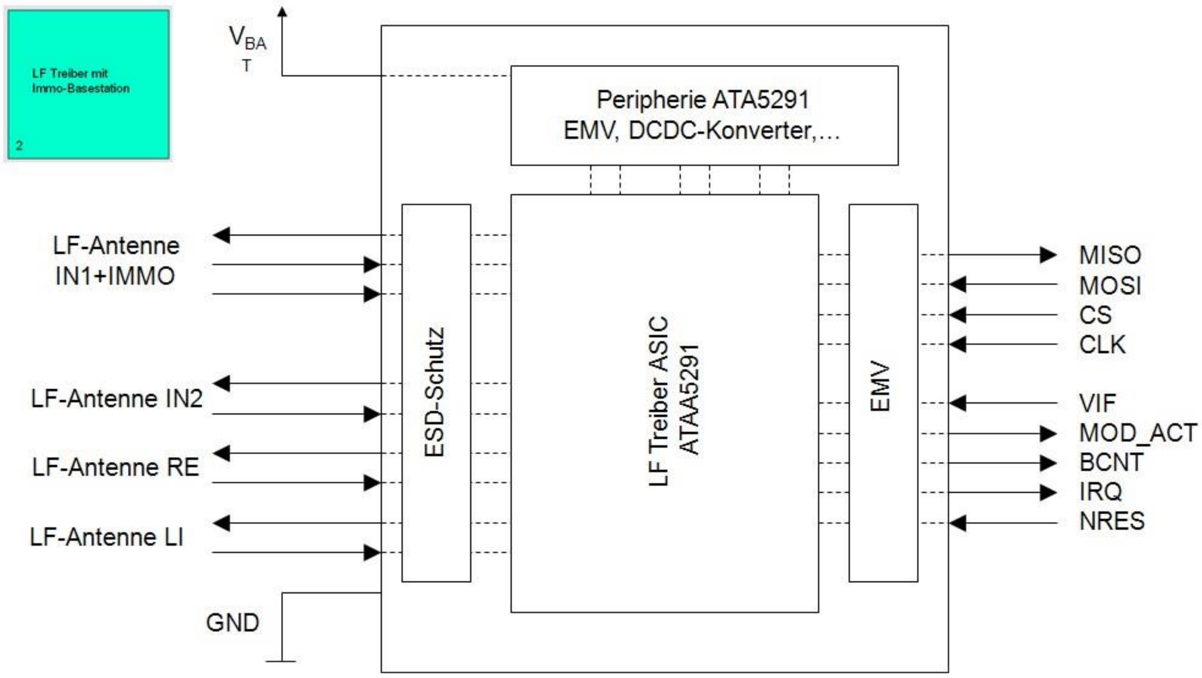


Fig. 13 Block diagram, LF driver module

4.1 Functional Description

4.1.1 General Function

The ATA5291 is the main part of generating a f=125kHz signal and drive it through four series resonant circuits, called LF antennas.

It is an ASIC with a sine-wave-generation circuitry to avoid noise in the AM-Band.

4.1.2 PEPS Tx Mode

This mode is used for passive entry, passive start (PEPS) data transmission. It is activated by sending the GPP() - "Go to PepsTxMode" SPI command. A 100% modulated carrier with a frequency of 125kHz is transmitted to the key fob. The output power is set by selecting one out of 19 regulated antenna current levels. The antenna current regulation can be carried out by means of an external resistor or an integrated current sensing circuit.

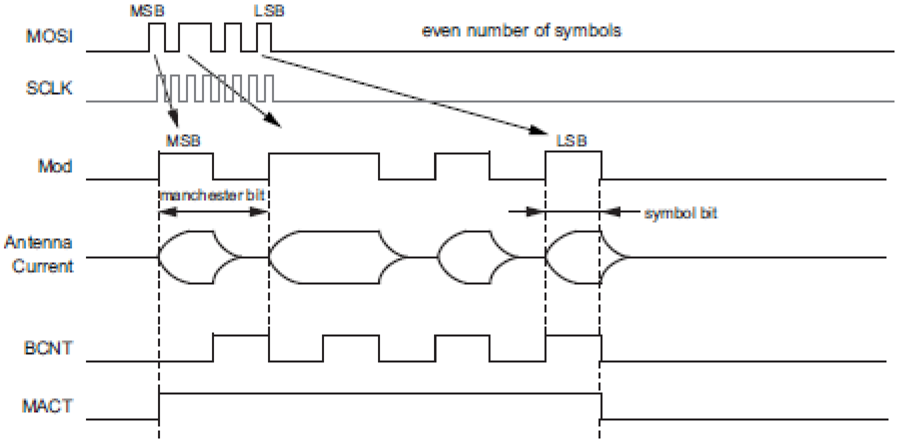
The AVCC18, AVCC33 voltage regulators and the PEPS front-end circuits are active. The booster circuit generates reliable VDS1 and VDS2 voltages even with variable VS input. The PEPS drivers require the VCP voltage to be higher than VDS. An internal charge pump provides the VCP voltage during transmission. The high accuracy oscillator is used as a clock and LF frequency reference. The VDS voltage is switched to VTX to achieve VTX = VDS, allowing the B0P driver to be connected directly to an AXP driver for shared coil applications.

A typical command sequence for PEPS transmission consists of:

- Entering the PEPS mode with the GPP() command
- Configuring the PEPS transmission, such as transmitting carrier and data with the SPC() and SPD() commands
- Returning with GID() to IdleMode after data transmission is completed.

Figure 4-2 shows some signals participating in a buffered PEPS transmission. The data input via SPI is shown on the MOSI and SCLK lines. The data is translated into a modulation signal (Mod) with the selected data rate. The antenna current changes in accordance with the modulation signal in relation to the antenna Q factor. The active data transmission can be monitored using the bit count (BCNT) and modulation active (MACT) output signals.

Figure 4-2. PEPS Transmission Signals



The Atmel® ATA5291 also supports regular autonomous wake-up pattern (WUP) transmission for polling operation. The required data and gap times are written to the TX control block and executed in a loop.

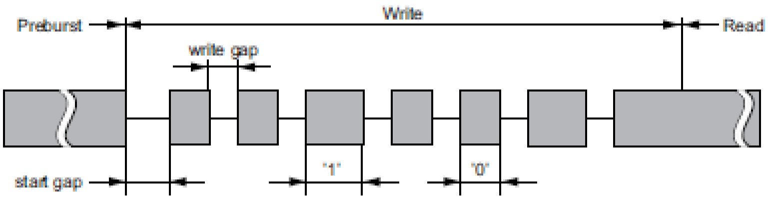
Fig. 14 Extract from Datasheet

4.1.3 Immo TxRx Mode

The ImmoMode is used to communicate with an immobilizer transponder. The AVCC18, AVCC33 voltage regulators and the IMMO front-end circuits are active. The booster circuit generates reliable VDS1 and VDS2 voltages even if the VS input varies. The VTX regulator generates a low noise voltage supply for the immobilizer driver and receiver circuits. The high accuracy oscillator is used as a clock and LF frequency reference.

The ImmoMode is activated by sending the GIM() - "Go to ImmoMode" SPI command to the Atmel ATA5291. A 125kHz carrier is transmitted by default when this mode is active. The energy transmitted by this carrier is used to power up the transponder. Data can be sent by using the SID() - "Send Immobilizer Data" command. The data is encoded in BPLM (binary pulse length modulation) or NRZ format and uses 100% ASK (OOK) modulation (see Figure 4-4). Length of gaps, zeroes and ones can be programmed over a wide range. In this way different transmission timings are possible to optimize power and data transfer simultaneously.

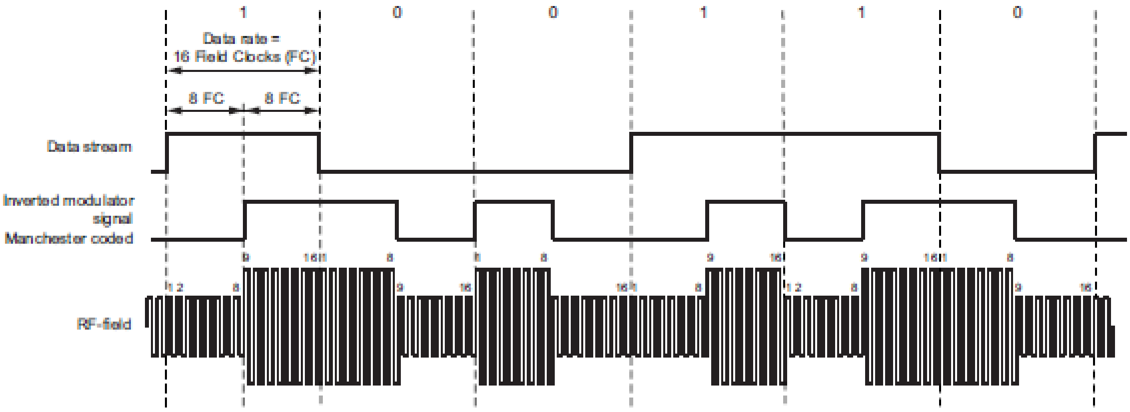
Figure 4-4. Reader to Transponder Write Sequence



The transponder response is expected during the Read phase. Load modulation (see Figure 4-5) with Manchester encoded data is typically used. This type of data transfer is also called full duplex mode (FDX). The Atmel® ATA5291 stores the received data symbol-based in the "Rx Buffer", for example a Manchester '0' in data stream will be stored as '1' and '0' in the "Rx Buffer". A fill level interrupt can be configured to signal a certain amount of received data by setting the IRQ pin to HIGH. The received data can be read out via SPI interface.

The ImmoMode should be activated with the GIS() - "Go to ImmoMode with shared coil" SPI command when one antenna coil is shared for PEPS and immobilizer operation.

Figure 4-5. Example of Transponder to Reader Modulation



Fully transparent transmission and reception operation is also possible with the shared MOSI/DIN and MISO/DOUT pins.

Fig. 15 Extract from Datasheet

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5 LF-Antennas

The LF antennas generate the magnetic field that is needed for wireless communication between car electronic components and the UID that is carried with by the end-user.

Each LF antenna that is plugged to the ECU is a LCR resonant circuitry:

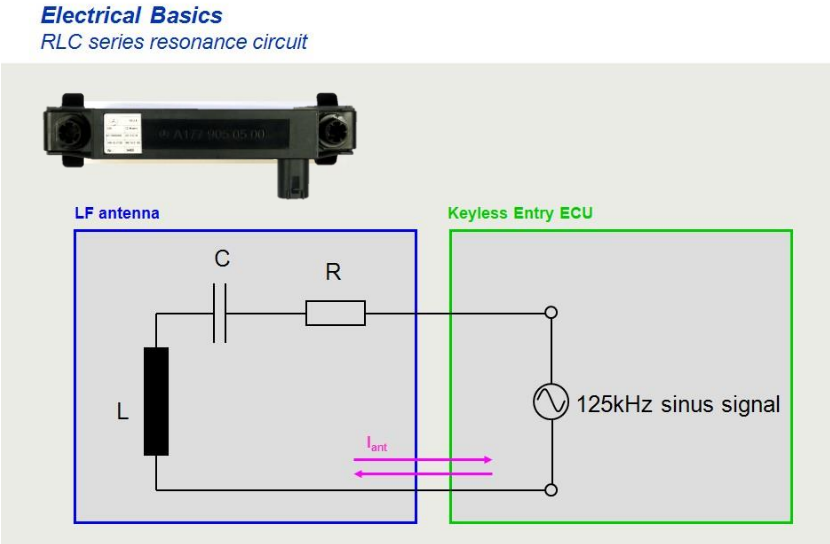

Fig. 16 LF Antenna, RLC resonant circuit

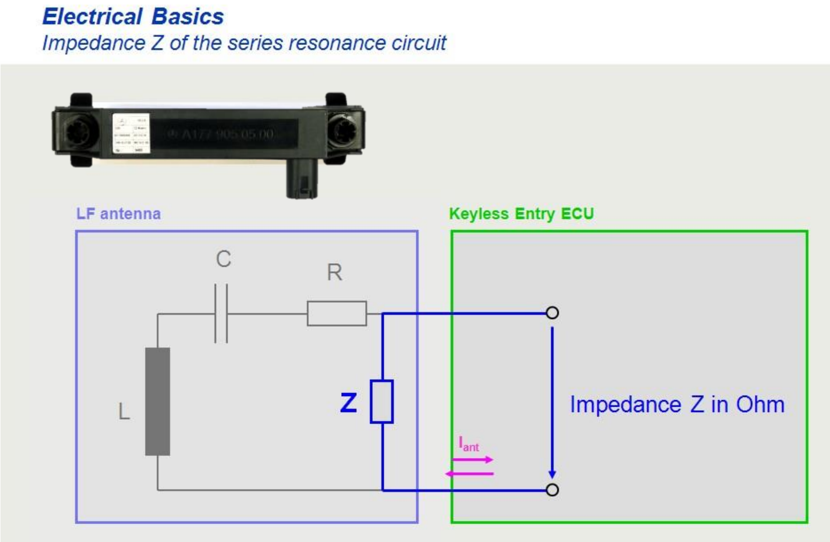

Fig. 17 LF-Antenna, Impedance Z

The LF antennas transmit the LF challenge signals (data) and the LF carrier wave signals. They are activated by the MAR EIS ECU using a controlled current.

ALL LF Antennas have the same efficiency.

The efficiency of all antennas is H_{max}(@l=1m, @I_{ANT}=500mA) =77,5 dBµA/m.

The general measurement of the efficiency of the antennas is shown is this picture:

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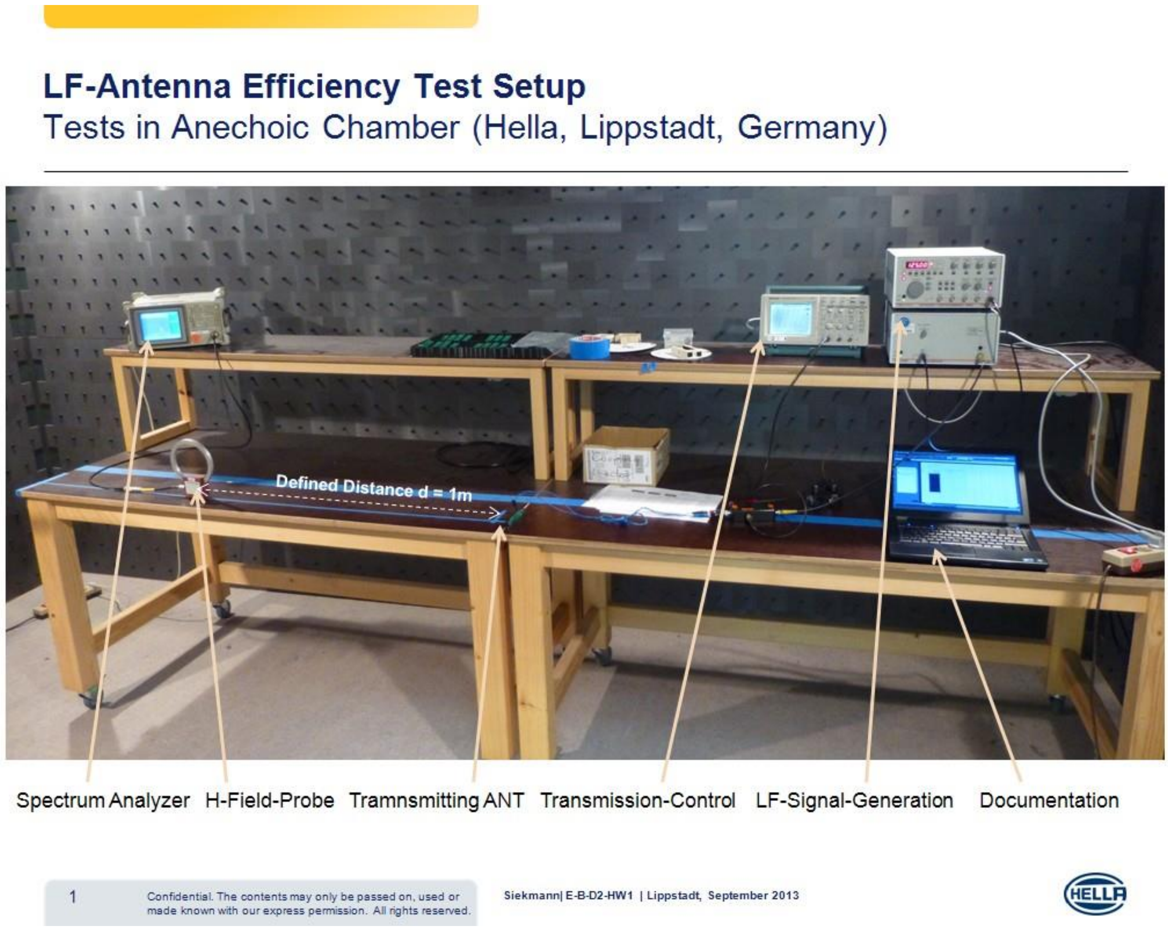


Fig. 18 LF-Antenna Efficiency Test Setup

The used LF antenna for homologation setup (the same as inside the car) has the following typical electrical parameters and is equal to ALL possible antennas in the system:

f_{res} = 125kHz

L = 326µH

R = 8Ohm

Z@125kHz = 12…18 Ohm

5.1 Documentation C2-Sample

5.1.1 Connection Schematic 207.308-00, A167 905 47 00

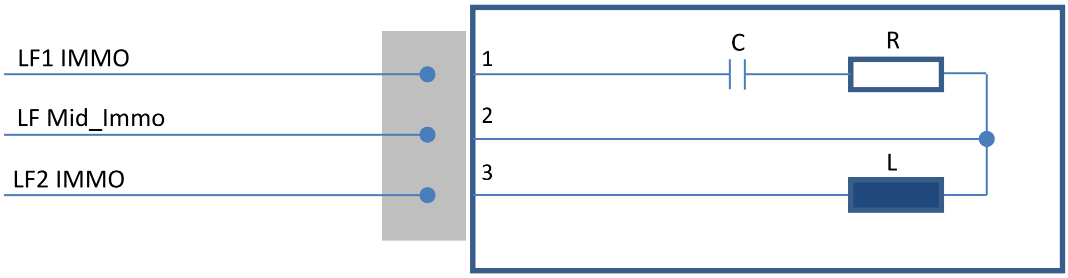


Fig. 19 Antenna Schematic

5.1.2 Picture of the C2-Sample Antenna

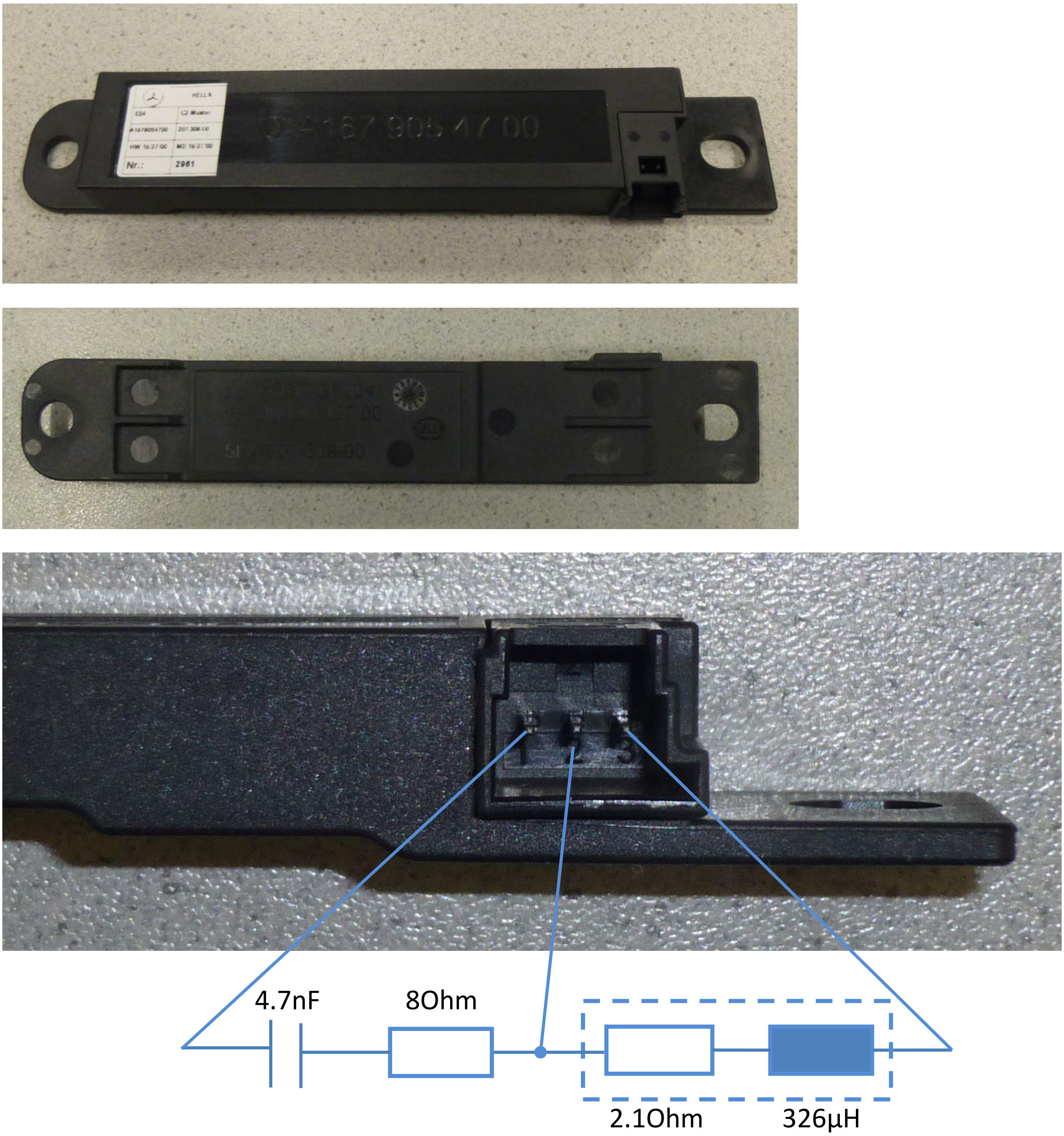


Fig. 20 Antenna housing and pinning

5.1.3 Mechanical Parameter

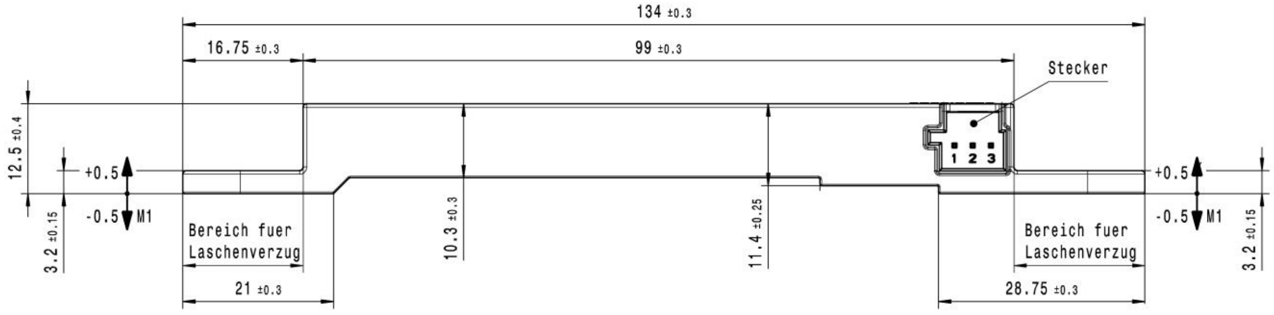


Fig. 21 Extract of the antenna part description

Hella 8303EN_GE (2004-09)

6 Software for LF Transmitter Mode (Data and CW) for Homologation

The LF Transmission for Homologation Purpose is an original LF Scan for a Passive Entry / Passive Exit action.

The LF driver IC is especially made for driving an electric current at f=125kHz with a certain modulation and bit structure. Only short burst shall be sent out at different antennas channels in a certain timing.

It is NOT possible to drive the antennas with a continuous carrier signal. The maximum of carrier (unmodulated) signal length that can be driven – and is driven for magnetic field strength measurement in the UID – is $t_{carrier}$=5,2ms.

The SW of the ECU has two small changes in comparison to the mass production software:
First:
As the setup is connected to the power supply (**V = 12V / I = 5A**) and the lever is set to “Open – LF Mode”, an **LF data scan** is automatically generated on all four antennas with a time gap of 23ms between each antenna and a pause of 273ms after the last antenna.

So, a continuous repetitive scanning is created, that is similar to the system reaction, as if a person is grabbing the door handle to enter the locked vehicle every 370ms with not having the UID in detection range.

Second:
As the setup is connected to the power supply (**V = 12V / I = 5A**) and the lever is set to “GND – IMMO Mode”, an **Immo transponder start** is automatically generated on the IMMO-antenna every 3,25s. After a successful keyfob answer the LED is powered for 100ms.

IMPORTANT NOTE: This **Second functionality** is only allowed to be used **1 Minute** and then a power down of 2 Minutes is needed. Otherwise the protocol won’t finish completely and the LED won’t light up due to warmup of the ECU. In mass production / series such a stress never would occur!

To switch between those two functions simply turn the lever in the designated position and perform a power-on reset.

There are no other SW changes to the mass production software.

The scope-diagrams in the following are taken by a simple AIR-COIL (15 windings, 4cm diameter), which is positioned near to the test setup. This coil is connected to a 150MHz Scope Probe (x10).

With this SW FOUR ANTENNAS are mentioned to the system.

6.1 LF Data Scan

6.1.1 Single Transmission LF Scan

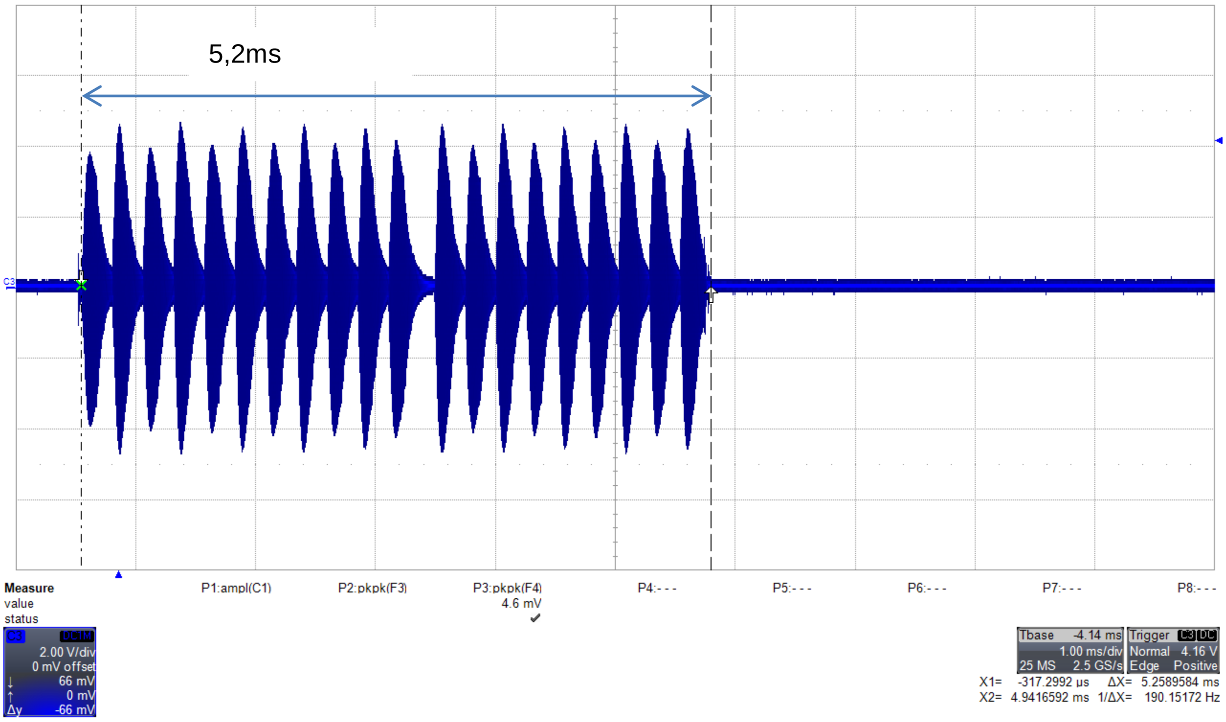


Fig. 22 Scope Shot from complete single LF scan

6.1.2 Single Transmission – f = 125kHz Oscillating Signal

The ECU drives a sinusoidal output signal. The frequency is f=125kHz. The magnetic field as the result is oscillating the same:

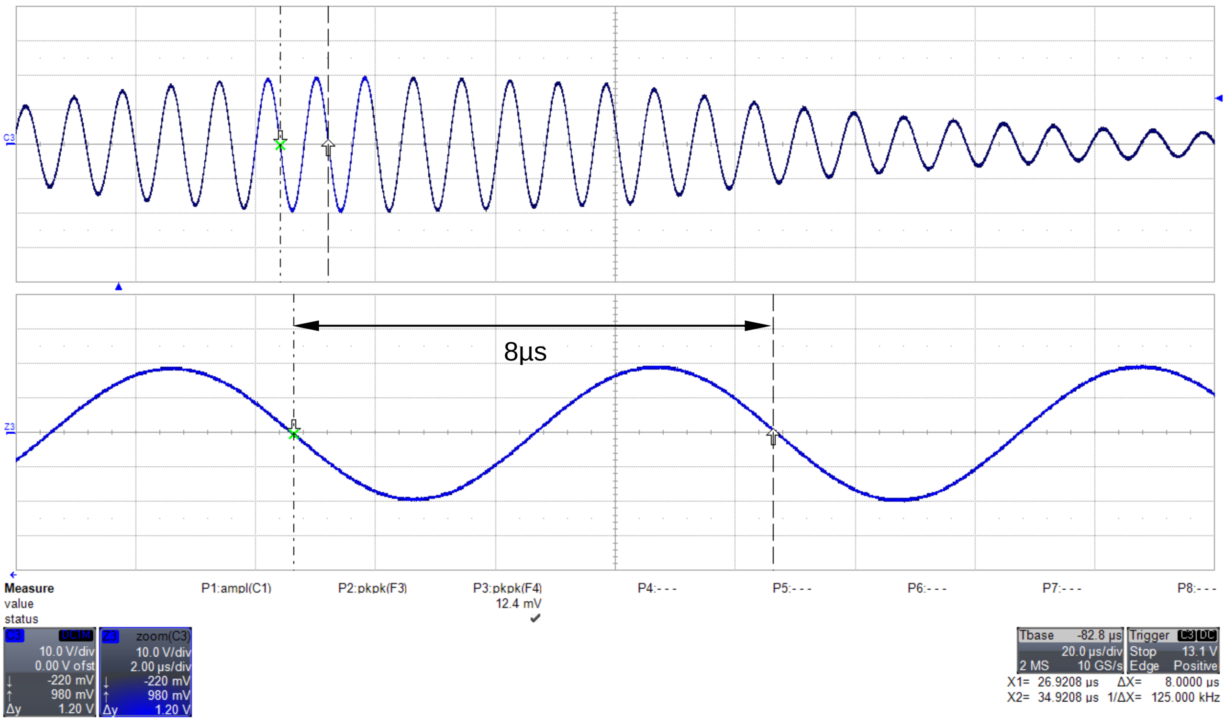


Fig. 23 Oscillating signal at f=125kHz

6.1.3 Repetition of Transmissions

All four LF-antennas are powered and the LF scan is repeated frequently due to homologation purpose:

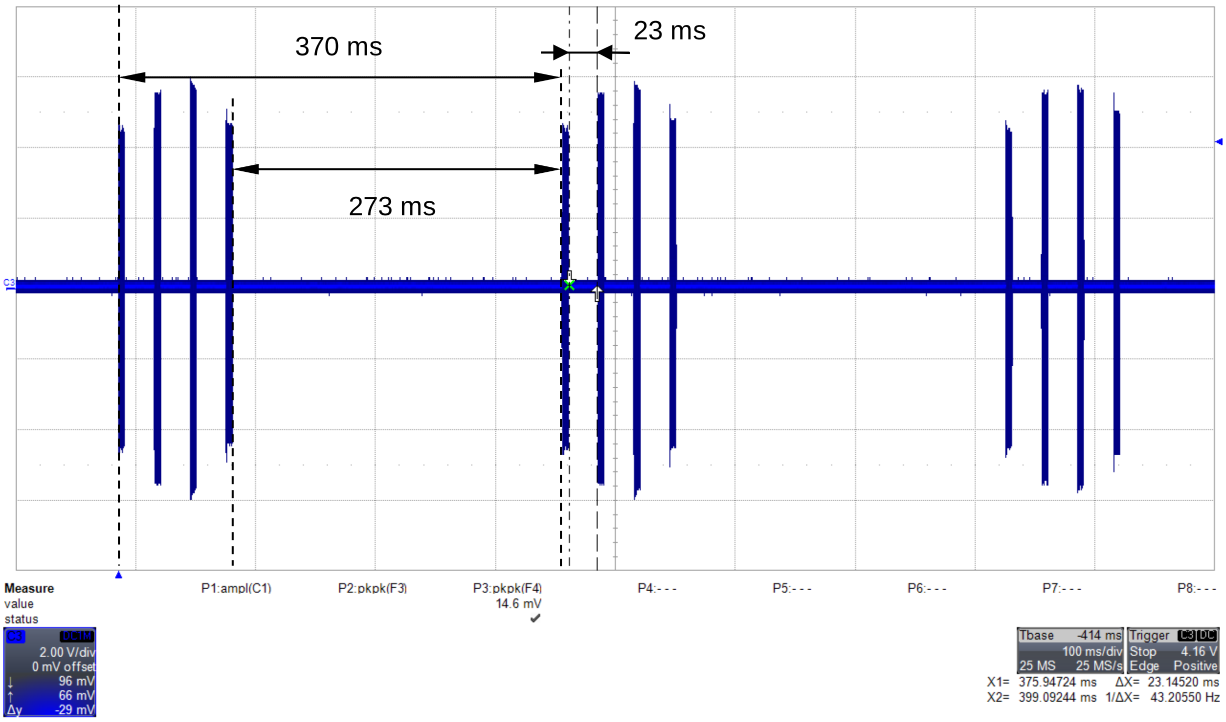


Fig. 24 LF-Signal repetition

6.2 IMMO Transponder Start

6.2.1 Single Transponder Start and Repetition of Transmissions

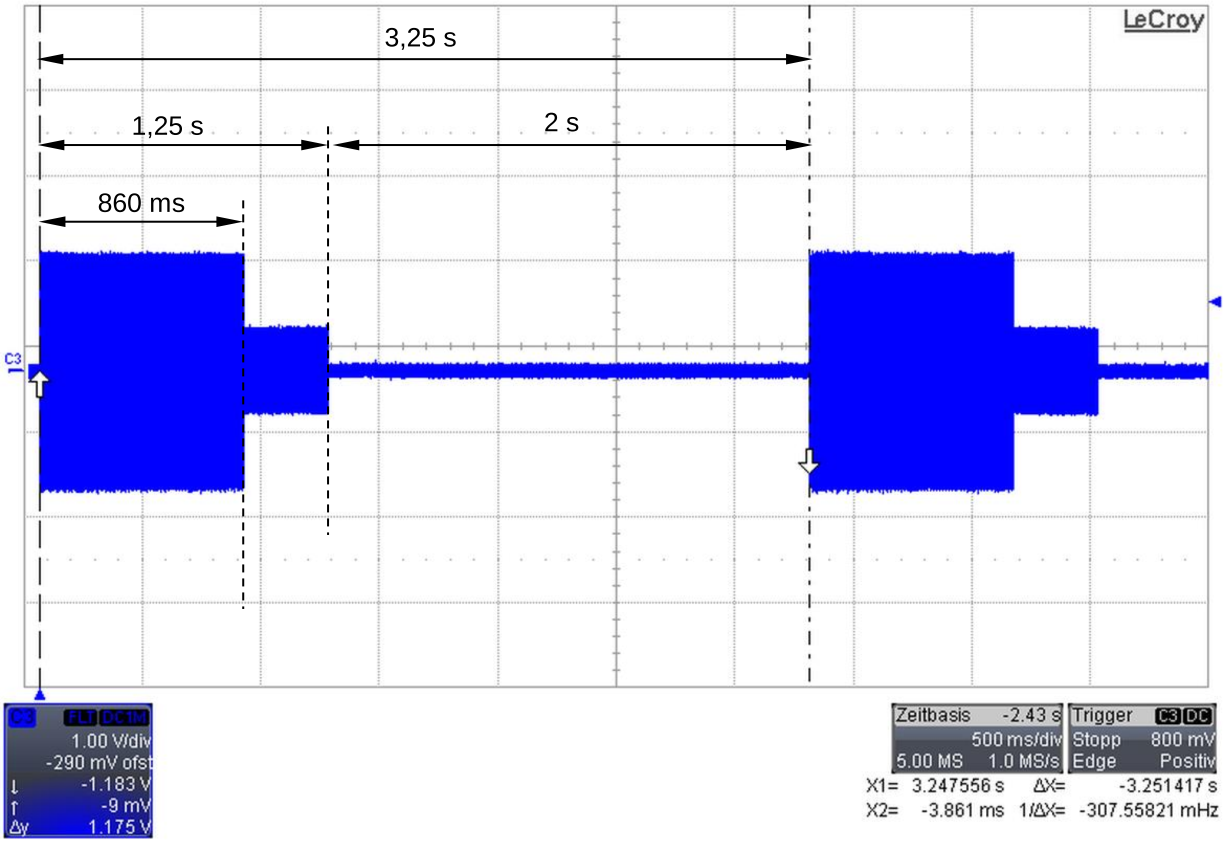


Fig. 25 Scope Shot of Transponder Transmission

6.2.2 Data Transmission

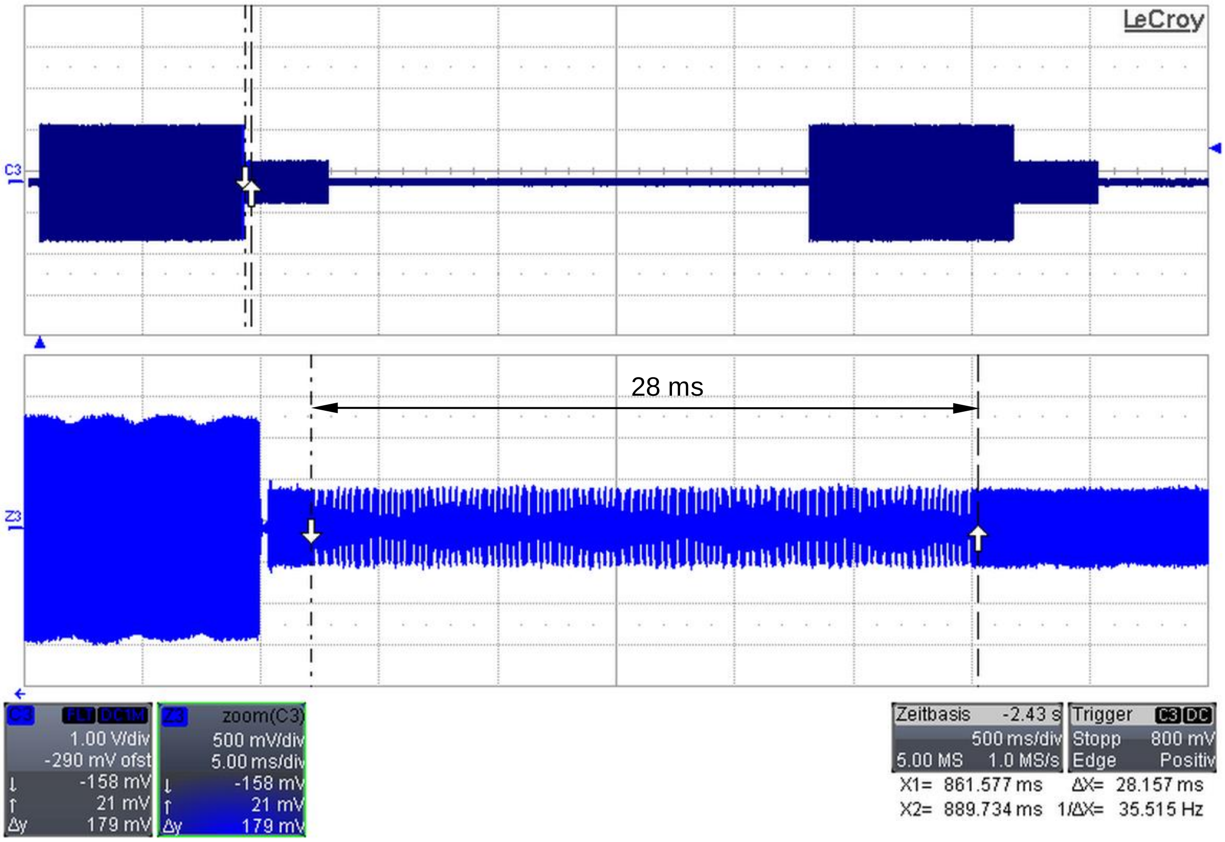


Fig. 26 Scope Shot of Data Transmission in in the Transponder Protocol

Hella 8303EN_GE (2004-09)

7 Test Set Up for Homologation

7.1 Setup in Block Diagram View

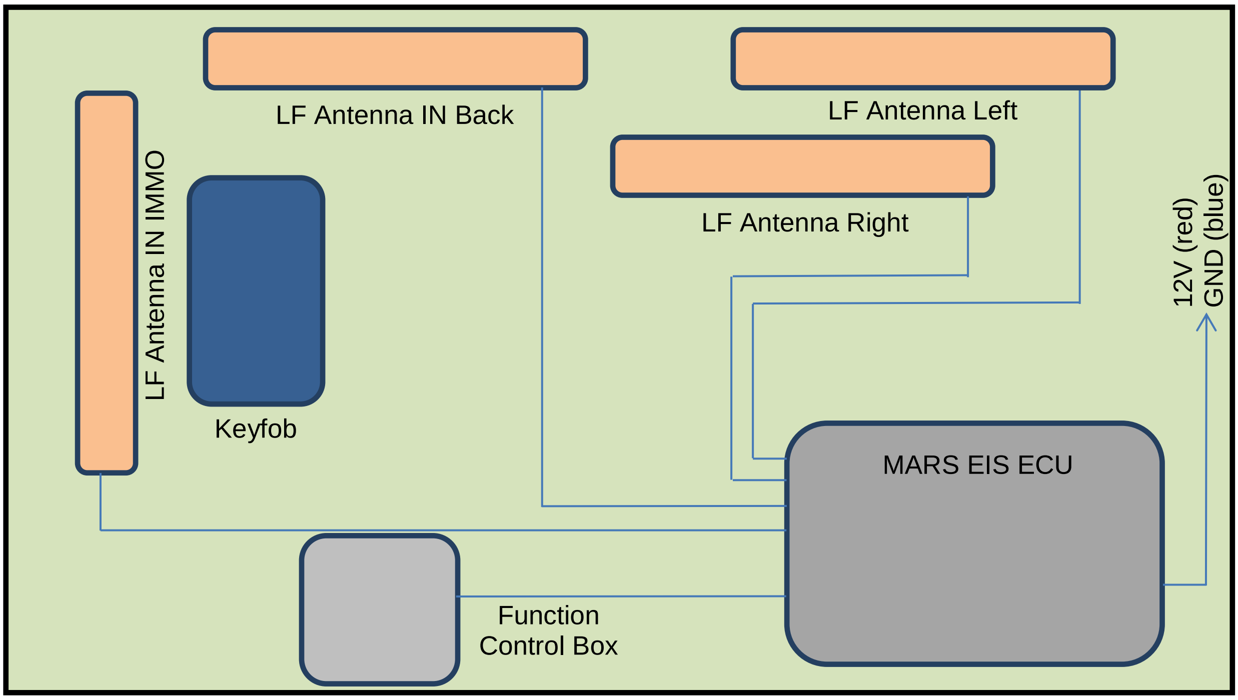
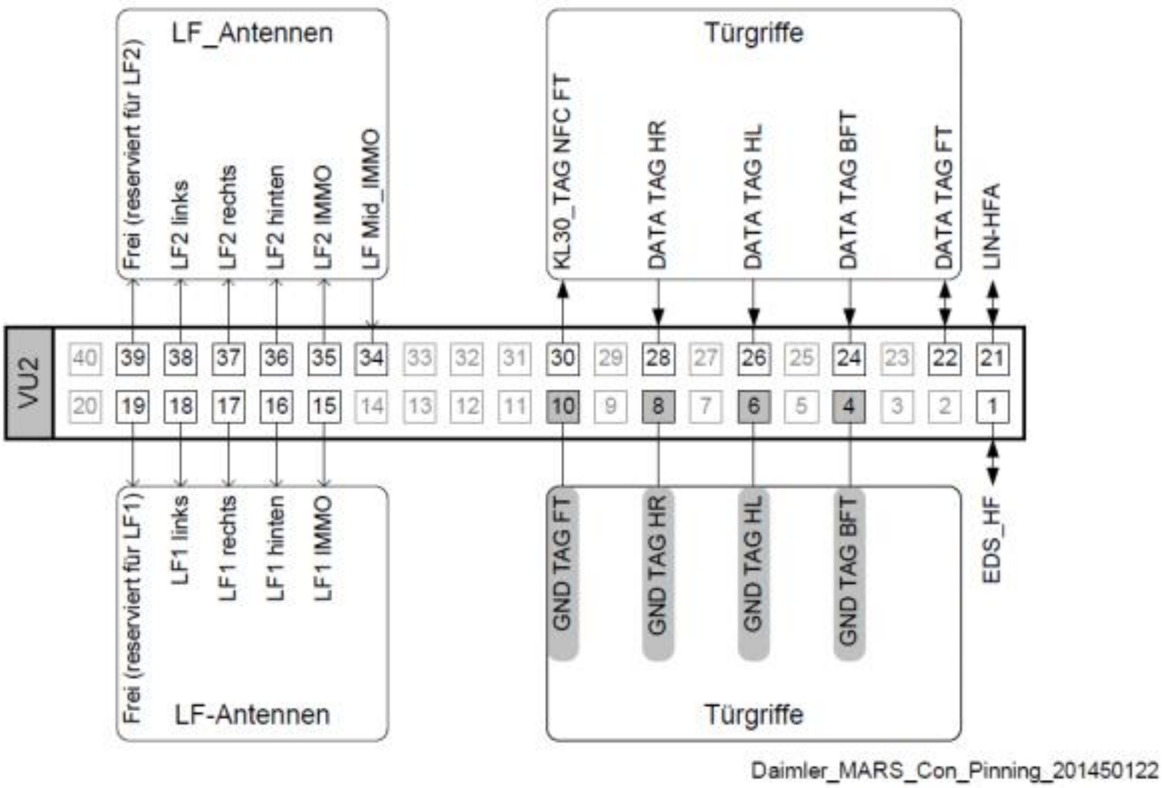


Fig. 27 Block diagram of the Test Setup

7.2 ECU and Connector Pinning for Hella design part



Connector Name	PIN (inside)	PIN (outside)	Connector name
LIN-HFA	21	1	EDS_HF
DATA TAG FT	22	2	
	23	3	
DATA TAG BFT	24	4	GND TAG BFT
	25	5	
DATA TAG HL	26	6	GND TAG HL
	27	7	
DATA TAG HR	28	8	GND TAG HR
	29	9	
KL30_TAG NFC FT	30	10	GND TAG FT
	31	11	
	32	12	
	33	13	
LF Mid_IMMO	34	14	
LF2 IMMO	35	15	LF1 IMMO
LF2 hinten	36	16	LF1 hinten
LF2 rechts	37	17	LF1 rechts
LF2 links	38	18	LF1 links
free (reserved for LF2)	39	19	free (reserved for LF1)
	40	20	

7.3 Components on Setup

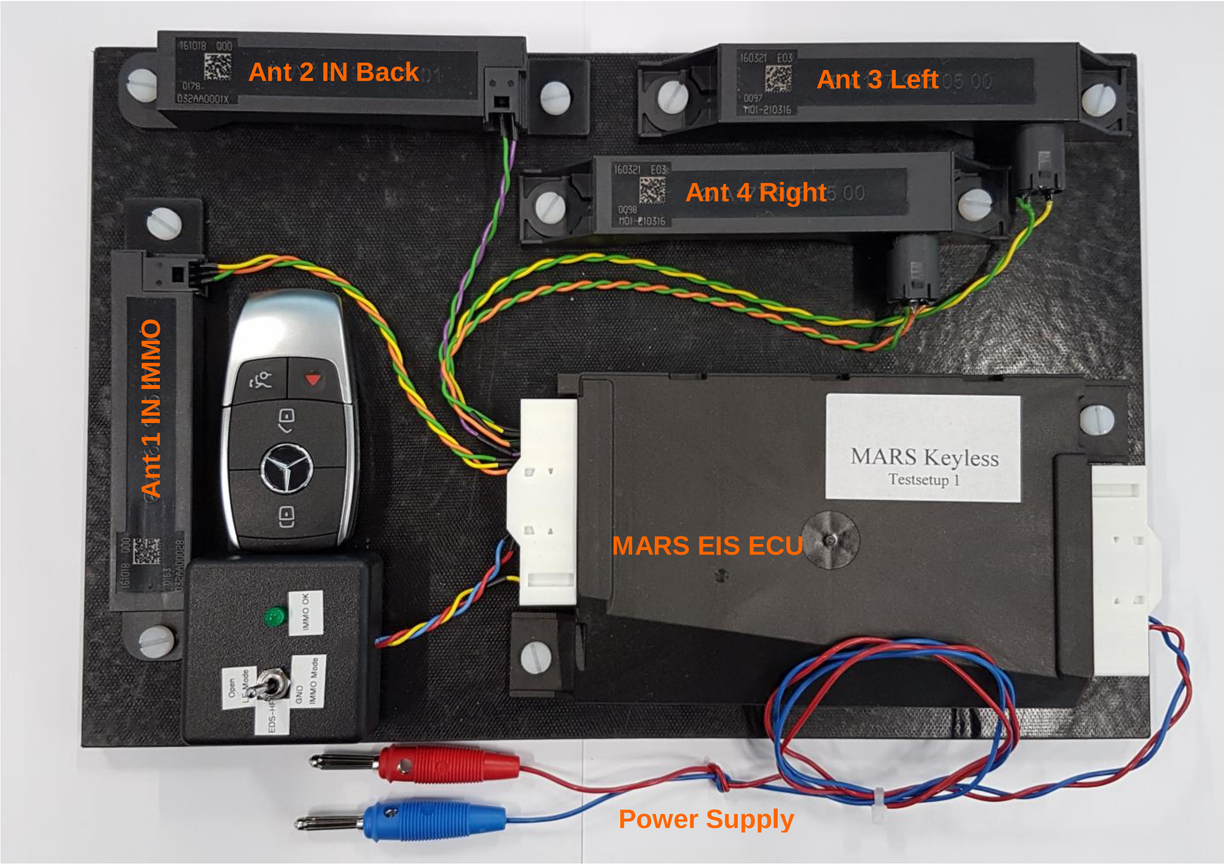
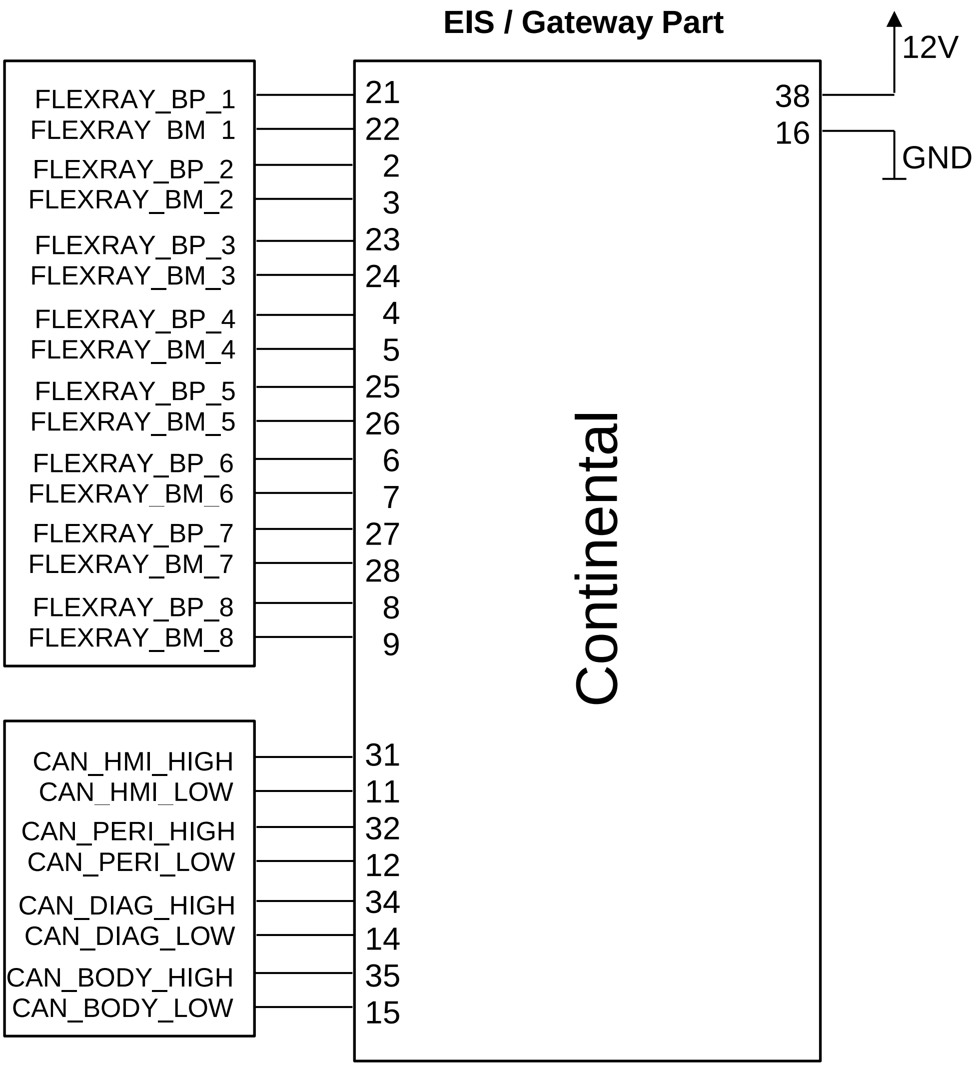
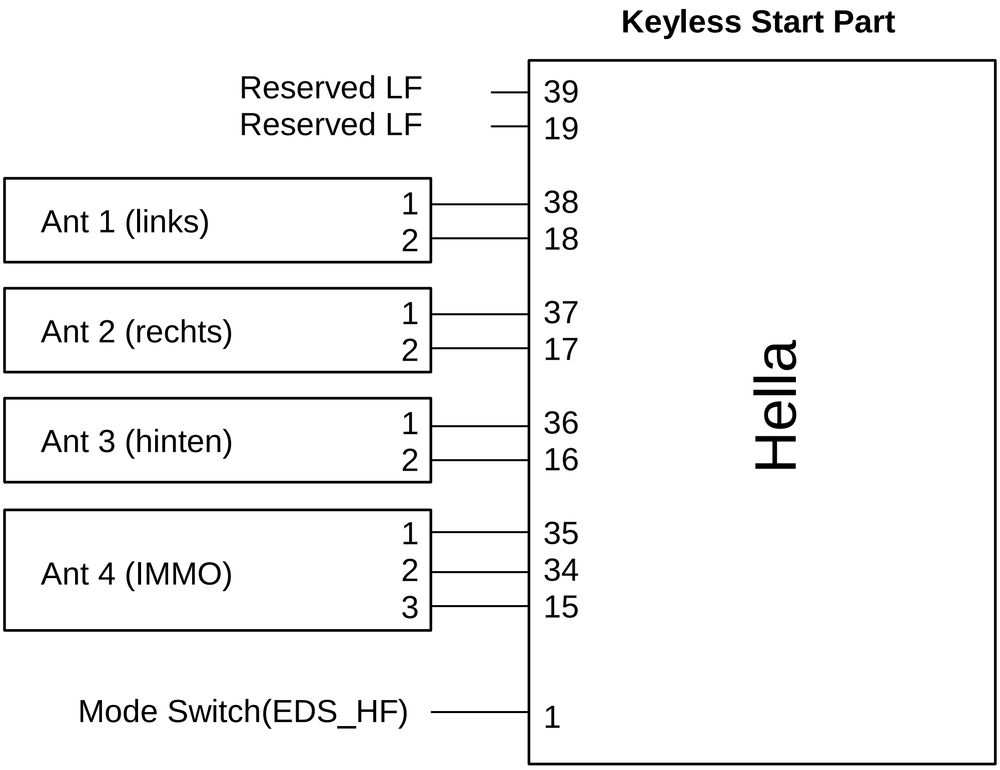


Fig. 28 Components on setup

7.4 Schematic



Hella 8303EN_GE (2004-09)



8 Housing views including Label

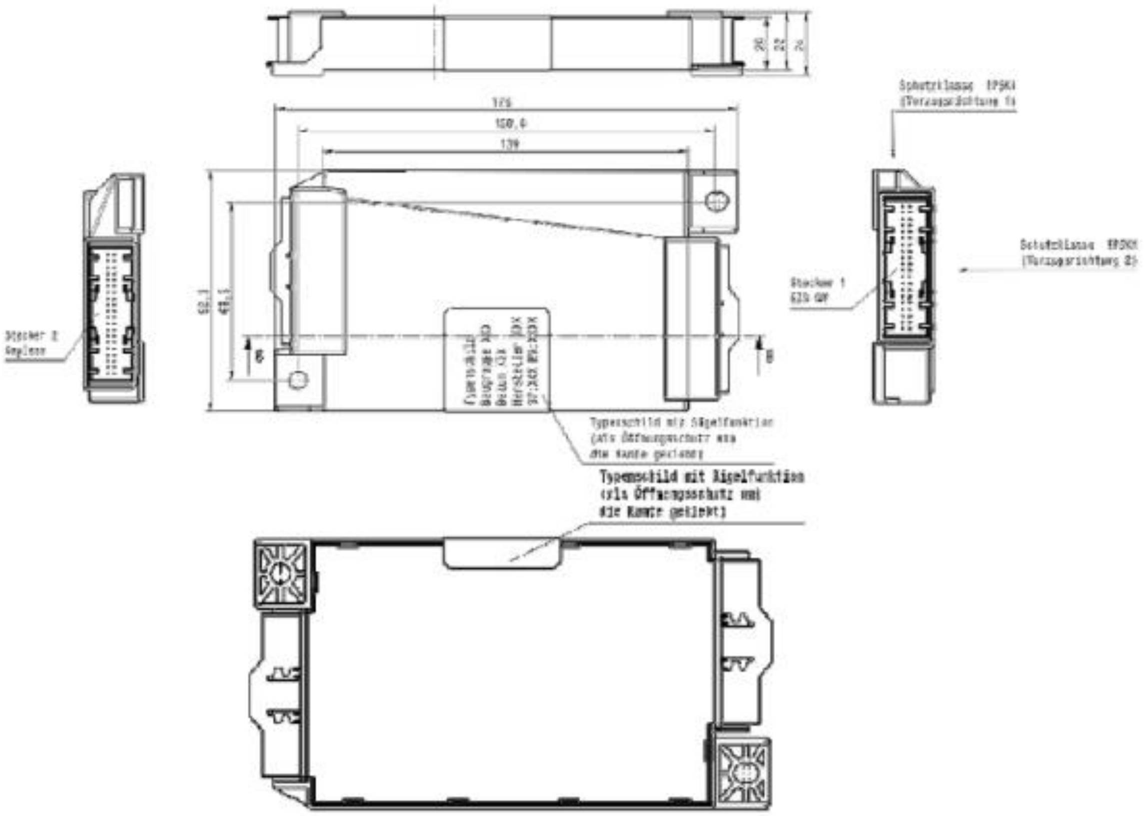


Fig. 29 Housing Top view (1) with details (2D)

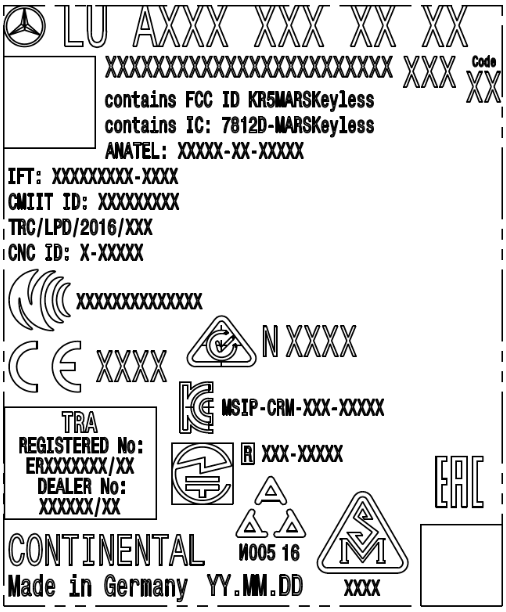


Fig. 30 Label (2D)

9 PHOTOS

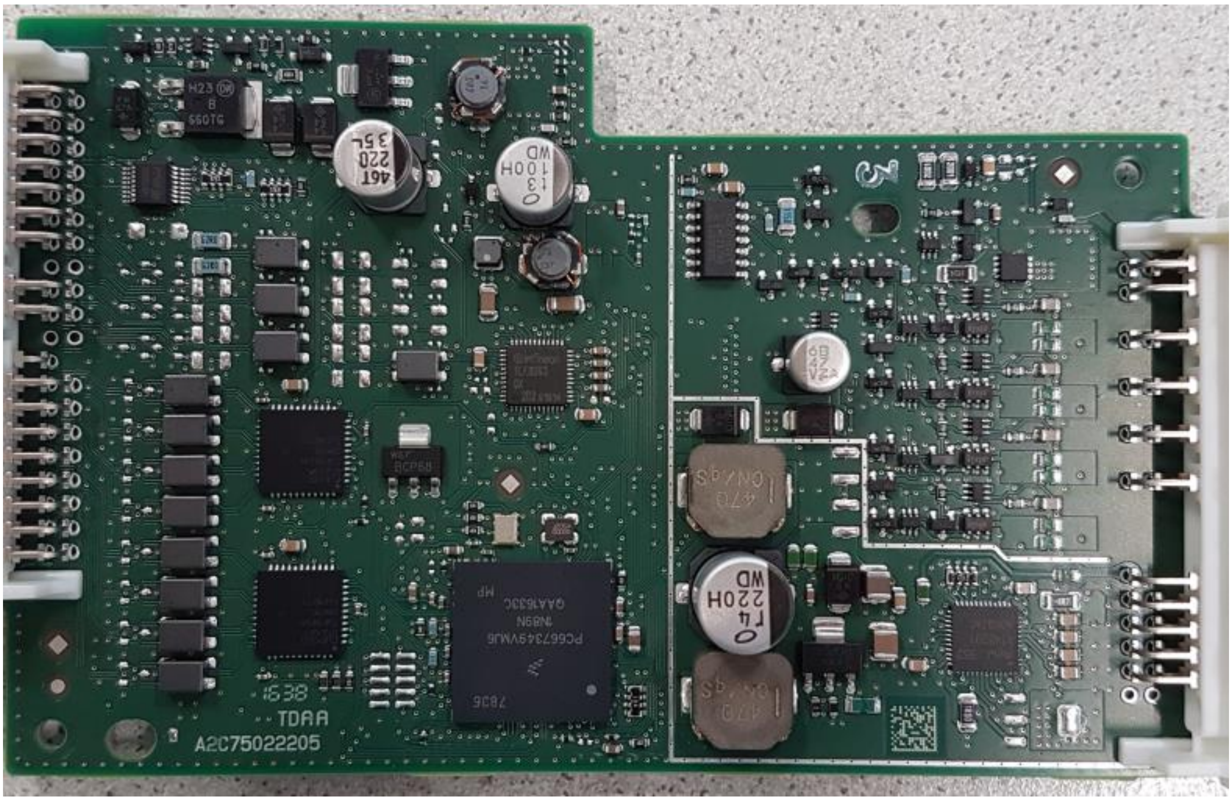


Fig. 31 MARS EIS ECU PCBA Top View

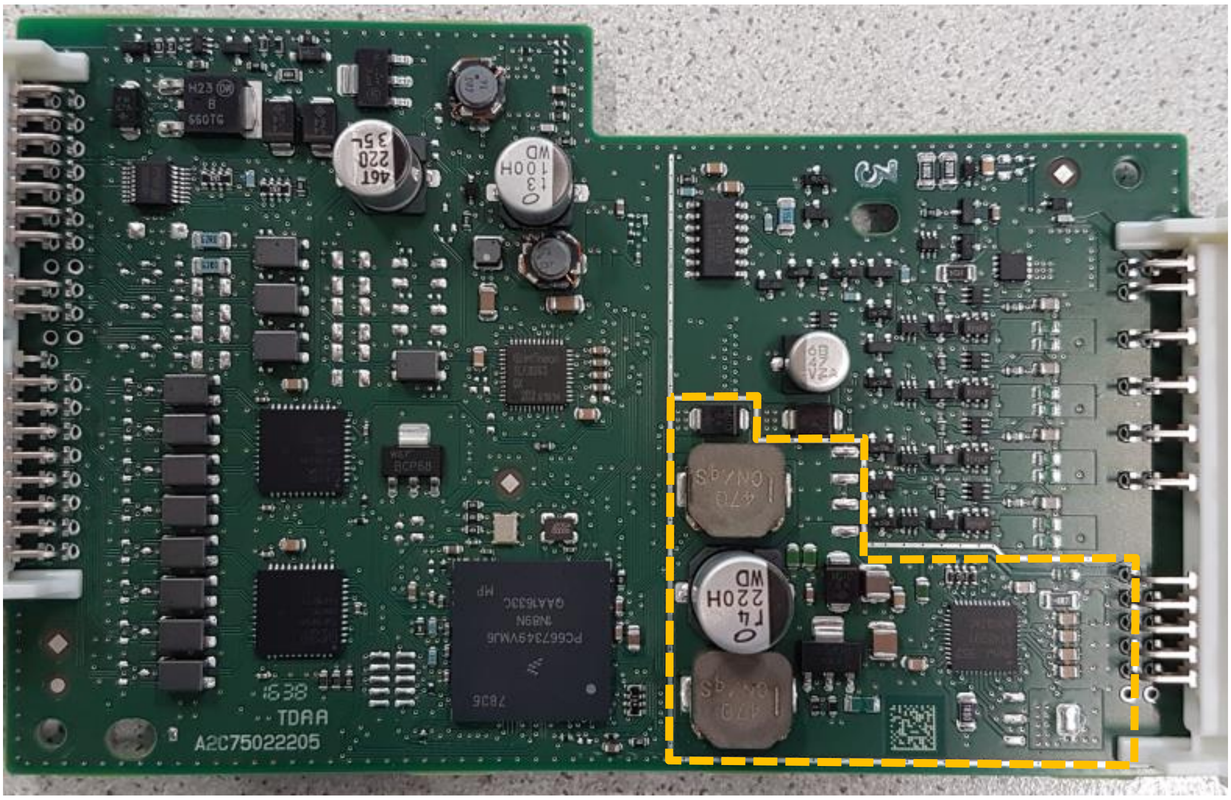


Fig. 32 MARS EIS ECU PCBA Top View with important module marked

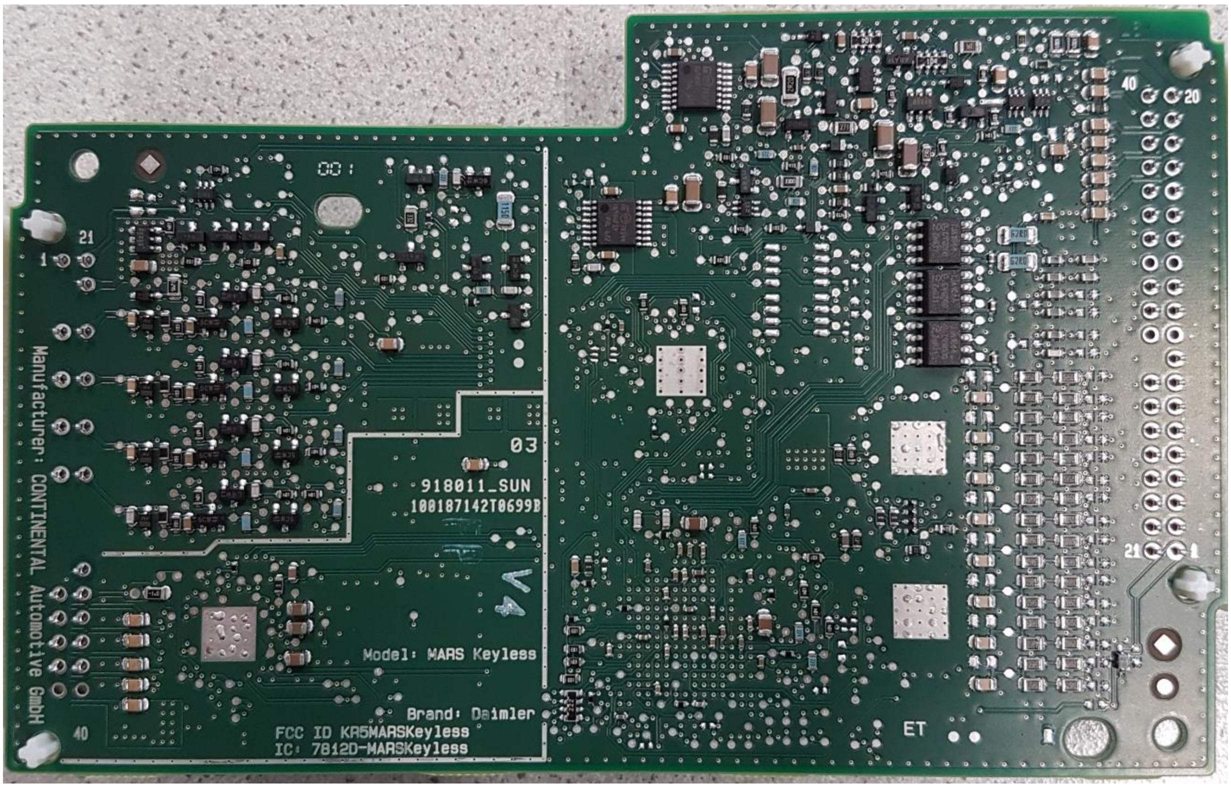


Fig. 33 MARS EIS ECU PCBA Bottom View

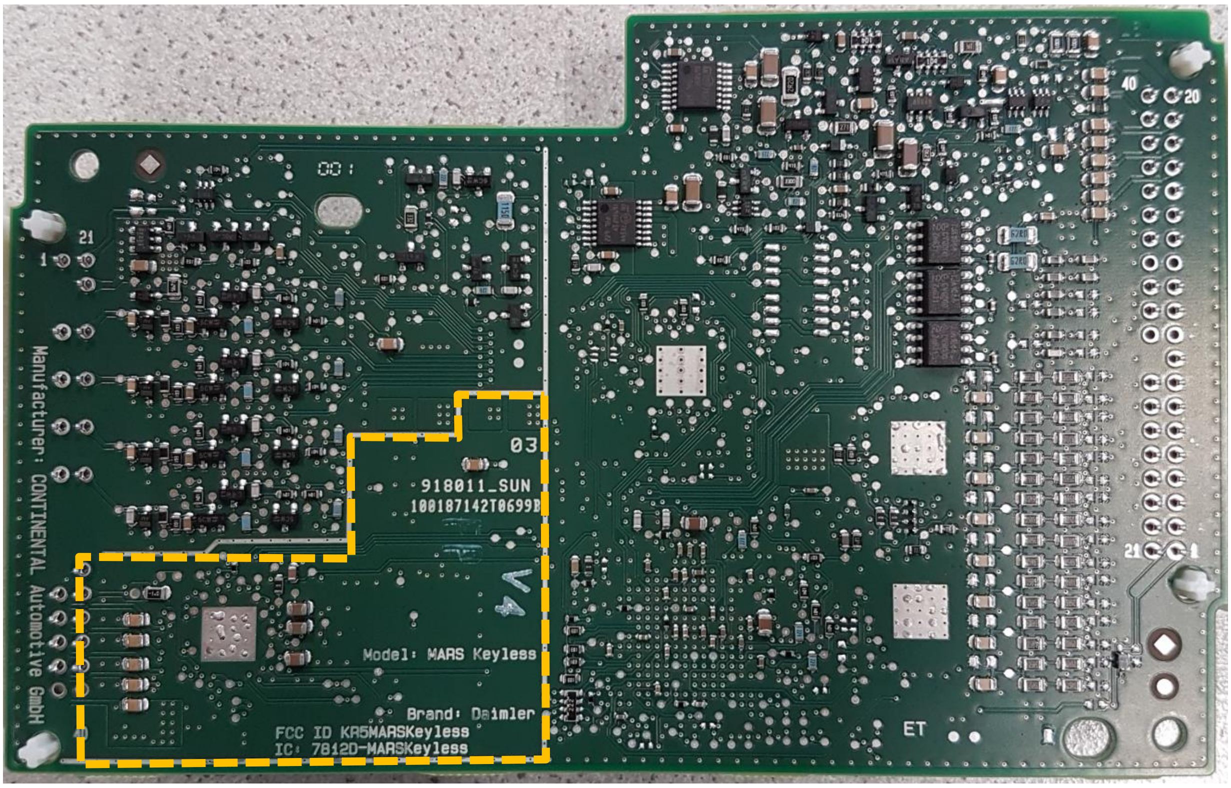


Fig. 34 MARS EIS ECU PCBA Bottom View with important module marked

10 Warning statement and Label information

According to 47 CFR 15.19 (labeling requirements) the car manufacturer will print the following text in the

appropriate User's Manual of the car:
This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:
(1) This device may not cause harmful interference, and
(2) this device must accept any interference received, including interference that may cause undesired operation.

Usually this is followed by the following FCC caution:
Any changes or modification not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.